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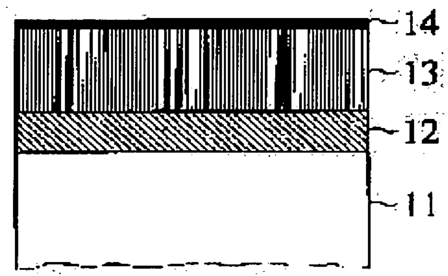
(54) PERPENDICULAR MAGNETIC RECORDING MEDIUM AND MAGNETIC RECORDER

(57)Abstract:
PURPOSE: To provide a medium excellent in crystal orienting property and having high perpendicular magnetic anisotropy by forming an under film with a Co-Ru alloy.
CONSTITUTION: A Co-Ru alloy forms a solid soln. over the entire compsn. range at ordinary temp. and the crystal structure is a hexagonal close-packed structure. An under film 12 of the Co-Ru alloy is formed on a nonmagnetic substrate 11 such as a glass substrate or an NiP coated Al alloy substrate. In the film 12, (0001) faces become parallel to the substrate and c-axes are liable to orient perpendicularly. A perpendicularly magnetized film 13 of a Co-based alloy and a protective film 14 are then formed on the film 12 to obtain the objective perpendicular magnetic recording medium. The proper concn. of Ru is ≥40at.% because a compsn. having ≥40at.% concn. of Ru gives ≤0° C Curie temp.



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CLAIMS

[Claim(s)]
[Claim 1] The vertical-magnetic-recording medium characterized by said substrate film consisting of an alloy of Co and Ru in the vertical-magnetic-recording medium which consists of a nonmagnetic substrate, the substrate film formed on said nonmagnetic substrate, perpendicular magnetic anisotropy films which consist of an alloy which uses as a principal component Co formed on said substrate film, and a protective coat formed on said perpendicular magnetic anisotropy films.
[Claim 2] A nonmagnetic substrate, the first substrate film formed on said nonmagnetic substrate, and the second substrate film formed on said first substrate film, In the vertical-magnetic-recording medium which consists of perpendicular magnetic anisotropy films of the alloy which uses as a principal component Co formed on said second substrate film, and a protective coat formed on said perpendicular magnetic anisotropy films The vertical-magnetic-recording medium characterized by for said first substrate film consisting of either Ti or Ru, and said second substrate film consisting of an alloy of Co and Ru.
[Claim 3] A vertical-magnetic-recording medium with Ru concentration of the layer which said substrate film which consists of an alloy of Co and Ru consists of film of a bilayer with which the concentration of Ru differs in claim 2, and is located directly under said perpendicular magnetic anisotropy films lower than Ru concentration of the layer located directly under it.
[Claim 4] The vertical-magnetic-recording medium by which the concentration of Ru is falling continuously toward said perpendicular-magnetic-anisotropy-films side in the substrate film which consists of said alloy of Co and Ru in a vertical-magnetic-recording medium according to claim 2 from the side near said nonmagnetic substrate.
[Claim 5] the substrate film which becomes either of claims 1-4 from said alloy of Co and Ru in the vertical-magnetic-recording medium of a publication -- setting -- the concentration of Ru -- 40at% -- the vertical-magnetic-recording medium which is more than Ru.
[Claim 6] The vertical-magnetic-recording medium priority orientation bearing of each of said substrate film and whose priority orientation bearing of said perpendicular magnetic anisotropy films are both [0001] in claims 1, 2, 3, or 4.
[Claim 7] The vertical-magnetic-recording medium which prepared detailed boom hoisting in the front face of said nonmagnetic substrate in claims 1, 2, 3, or 4.
[Claim 8] The magnetic recording medium which has a control means for controlling the migration means for moving the relative position of the magnetic head for recording information and reproducing, said magnetic head, and said vertical-magnetic-recording medium to the holder for holding a vertical-magnetic-recording medium according to claim 1, 2, 3, 4, 5, 6, or 7 and said vertical-magnetic-recording medium, and said vertical-magnetic-recording medium, and these each part.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the magnetic recording medium using a vertical-magnetic-recording medium and it equipped with the magnetic film suitable for high density magnetic recording.
[0002]
[Description of the Prior Art] Against the background of development of an information society, a lot of information is accumulated and the demand to the magnetic recording medium which can be outputted and inputted at a high speed is increasing increasingly. In order to record more information on a compact, instead of the magnetic-recording method within a field used from the former, vertical magnetic recording has attracted attention as a new recording method which can improve recording density further.
[0003] A vertical magnetic recording is the recording method which makes a record unit the magnetization perpendicularly formed to the front face of a record medium, and since the effect of the anti-field in a flux reversal part becomes small, it is thought that it is suitable for high density record. This is IEEE. Transactions ON It is described by MAGUNE tex (IEEE Transactions on Magnetics) and the MAG-13 (1977) 1272 page paper. The record medium used for this vertical magnetic recording needs to have an easy axis in the direction perpendicular to a medium front face, and needs to have a big magnetic anisotropy. For this reason, researches and developments of the thin film medium in which perpendicular magnetic anisotropy films were formed on the substrate have been done.
[0004] Using large Co alloy of a magnetic anisotropy for the record film of a vertical-magnetic-recording medium has been examined from the former. Co alloys, such as a CoCr alloy, have hexagonal-closest-packing structure, and the uniaxial magnetic anisotropy which uses the c-axis as an easy axis is shown. If the thin film of Co alloy is formed in the front face of amorphous substrates, such as glass, the polycrystal thin film which the field which is the atomic maximum dense side (0001) [0001]-orientation-made it easy to become parallel to a substrate side will be obtained. Although this film showed the perpendicular magnetic anisotropy, in order to have used as a vertical-magnetic-recording medium, it needed to give a still bigger magnetic anisotropy.
[0005] Then, the substrate film was prepared on the substrate and the attempt which raises the c-axis stacking tendency of Co alloy magnetic film has been made. Since it is easy to carry out [0001] orientation of the thin film with hexagonal-closest-packing structures, such as Ti, it is reported that the stacking tendency of Co alloy magnetic film is improvable using this as substrate film. The vertical-magnetic-recording medium using Ti substrate film is described by IEEE Transactions on Magnetics and MAG-19 (1983) 1644 page at the paper of a publication.
[0006] However, the magnitude of distribution of the c-axis of Co alloy magnetic film formed on such Ti substrate film was not able to say that it was sufficiently small, either. It is thought that it is to confuse a stacking tendency at the time of initial growth of Co alloy since this cause has the difference of the lattice constant of Ti and Co alloy as large as 15%. Then, development of the new substrate film for raising further the c-axis stacking tendency of Co alloy magnetic film was desired.

[0007]
[Problem(s) to be Solved by the Invention] Compared with Co alloy film formed on the conventional substrate film, the purpose of this invention is further excellent in a crystal stacking tendency, and is to offer [offering a vertical-magnetic-recording medium with a big perpendicular magnetic anisotropy, and] the magnetic recording medium using it.
[0008]
[Means for Solving the Problem] As shown in drawing 1 , the vertical-magnetic-recording medium of this invention is a vertical-magnetic-recording medium which consists of the nonmagnetic substrate 11, the substrate film 12 formed on the substrate, perpendicular magnetic anisotropy films 13 of the alloy which uses as a principal component Co formed on the substrate film, and a protective coat 14 formed on perpendicular magnetic anisotropy films, and is characterized by the ingredient of the substrate film being the alloy of Co and Ru.
[0009] As the second description of the vertical-magnetic-recording medium of this invention is shown in drawing 2 , the nonmagnetic substrate 21, The first substrate film 22 formed on the substrate, and the second substrate film 23 formed on the first substrate film, It is the vertical-magnetic-recording medium which consists of perpendicular magnetic anisotropy films 24 of the alloy which uses as a principal component Co formed on the second substrate film, and a protective coat 25 formed on perpendicular magnetic anisotropy films, and is in the first substrate film consisting of either Ti or Ru, and the second substrate film consisting of an alloy of Co and Ru.
[0010] By the vertical-magnetic-recording medium of the configuration of the second of this invention (1) Ru concentration of the layer which the substrate film which consists of an alloy of Co and Ru consists of film of a bilayer with which the concentration of Ru differs, and is located directly under perpendicular magnetic anisotropy films is smaller than Ru concentration of the layer located directly under this layer, (2) It is good also as a configuration in which it is satisfied with the substrate film which consists of an alloy of Co and Ru whether they are that the concentration of Ru is falling continuously toward a perpendicular-magnetic-anisotropy-films side from the side near a substrate, and ********.
[0011] the substrate film which consists of an alloy of Co and Ru by the vertical-magnetic-recording medium of the second configuration for a start [of this invention] -- the concentration of Ru -- 40at(s)% -- the description is in being more than Ru.
[0012] Moreover, by the vertical-magnetic-recording medium of the second configuration, the description is for a start [of this invention] for perpendicular magnetic anisotropy films 13 and 24 and the substrate film 12, 22, and 23 to carry out [0001] preferred-orientation orientation for all.
[0013] It is still better for a start [of this invention] also as a configuration which established boom hoisting detailed on the front face of substrates 11 and 21 by the vertical-magnetic-recording medium of the second configuration.
[0014] The magnetic recording medium of this invention consists of control means for controlling the migration means for moving the relative position of the magnetic head for recording information and reproducing, the magnetic head, and a vertical-magnetic-recording medium to the holder for holding the vertical-magnetic-recording medium by the second configuration, and a vertical-magnetic-recording medium for a start which was explained above, and a vertical-magnetic-recording medium, and these each part.
[0015]
[Function] It is known that the CoRu alloy used for the above-mentioned configuration will build the solid solution with ordinary temperature over all presentation range. The crystal structure is hexagonal-closest-packing structure as well as Co and Ru. If the thin film of this alloy is formed on a substrate with an amorphous front face like aluminum alloy substrate which coated a glass substrate and NiP, a field (0001) will become parallel to a substrate and it will be easy to carry out perpendicular orientation of the c-axis. For this reason, it can use as substrate film for raising the c-axis perpendicular stacking tendency of Co alloy magnetic film used as record film of a vertical-magnetic-recording medium. Since Curie temperature becomes [the concentration of Ru] 0 degree C or less in the presentation region beyond 40at%, this alloy stops showing

ferromagnetism. the case where it uses as nonmagnetic substrate film -- the concentration of Ru -- 40at(s)% -- using in the range more than Ru is appropriate.
[0016] The lattice constant of a CoRu alloy changes continuously in proportion to the presentation of an alloy. The lattice constants of the a-axis of Co and Ru are 0.251nm and 0.270nm, respectively. The lattice constant of Co-40at%Ru is 0.259 nm. Therefore, if the alloy of Co-40at%Ru is used for the substrate film, the difference of a lattice constant with Co alloy magnetic film (the lattice constant of an a-axis is about 0.25nm) will become small with -3% on the basis of a CoRu alloy. Therefore, if this alloy is used as substrate film, turbulence of the orientation at the time of initial growth of Co alloy can be prevented, and the high perpendicular magnetic anisotropy films of a c-axis perpendicular stacking tendency can be produced.
[0017] Although it is easy to carry out c-axis perpendicular orientation of Ru and Ti, when using Ru for the substrate film and using Ti -7%, the difference of the lattice constant of an a-axis with Co alloy magnetic film becomes -15%, is compared with the case of a CoRu alloy, and is large. [of a gap] Then, after forming the substrate film of Ti or Ru, by forming the CoRu alloy substrate film in the front face, a lattice constant difference can be eased and the substrate film with the lattice constant near the lattice constant of Co alloy can be produced.
[0018] Furthermore, a lattice constant difference can be effectively eased by considering the CoRu alloy substrate film as the configuration which consists of film of a bilayer with which Ru concentration differs, forming a layer with high Ru concentration on the substrate film of Ti or Ru, and forming a layer with low Ru concentration in the front face. Moreover, a lattice constant difference can be eased also by reducing Ru concentration of the CoRu alloy substrate film continuously toward a perpendicular-magnetic-anisotropy-films side from the side near a substrate.
[0019] Thus, by using a CoRu alloy with the lattice constant near the lattice constant of the a-axis of Co alloy magnetic film for the substrate film, the c-axis perpendicular stacking tendency of Co alloy magnetic film is raised, and the vertical-magnetic-recording medium which fitted high density record conventionally can be offered.
[0020]
[Example]
<Example 1> diameter 2.5 The magnetic-recording medium with cross-section structure as shown in drawing 3 R> 3 was produced by the DC magnetron sputtering method using the glass substrate of an inch. The CoRu alloy substrate film 32, 32', Co alloy magnetic film 33, 33', the carbon protective coat 34, and 34' are formed in both sides of a substrate 31 in this sequence.
[0021] It formed in membrane formation using argon gas on conditions with pressure 0.7 Pa of gas, a substrate temperature [of 260 degrees C], and a membrane formation rate of 50nm/m. The presentation of the target which uses for formation of Co-40at%Ru and a magnetic film the presentation of the target used for formation of the substrate film was set to Co-15at%Cr-5at% Ta. The die length of the a-axis of Co alloy magnetic film of this presentation was 0.251 nm. 100nm and a carbon protective coat set [the CoRu alloy substrate film / 50nm and Co alloy magnetic film] thickness of each film to 10nm. All the above-mentioned film formation was performed continuously, without breaking a vacuum within the same vacuum tub.
[0022] According to the X diffraction, magnetic properties were measured for the crystal orientation of the produced sample using the sample oscillatory type magnetometer (VSM), respectively. In the X diffraction, it turned out that the 0002 diffraction peak of the CoRu alloy substrate film and Co alloy magnetic film is observed, and this film is carrying out [0001] orientation. When the locking curve of the X-ray 0002 diffraction peak of Co alloy magnetic film was measured, as compared with the magnetic-recording medium completely produced on the same conditions, without using the substrate film for the magnetic-recording medium of this example, the half-value width of a locking curve was decreasing and the [0001] orientation of Co alloy magnetic film is improved. Improvement of the coercive force of a film surface perpendicular direction was carried out 38% (420Oe).
[0023] The improvement effect was accepted also when a Co-50at%Ru alloy and a Co-75at%Ru alloy were furthermore used for the substrate film. These results are shown in Table 1.
[0024]

[Table 1]

表　1

下地膜	a軸の長さ (nm)	X線ロッキング曲線の半値幅(度)	垂直方向の保磁力(Oe)
Co−40at%Ru	0.259	2.8	1520
Co−50at%Ru	0.261	3.1	1490
Co−75at%Ru	0.265	3.1	1470
なし (比較例)		8.5	1100

[0025] <Example 2> Diameter 1.8 The magnetic-recording medium with cross-section structure as shown in drawing 4 was produced by the DC magnetron sputtering method using aluminum alloy substrate which coated NiP of an inch. The first substrate film 42 which consists of Ru, 42', the second substrate film 43 which consists of a CoRu alloy, 43', Co alloy magnetic film 44, 44', the carbon protective coat 45, and 45' are formed in both sides of a substrate 41 in this sequence.
[0026] It formed in membrane formation using argon gas on conditions with pressure 0.7 Pa of gas, a substrate temperature [of 260 degrees C], and a membrane formation rate of 50nm/m. The presentation of the target which uses for formation of Co-40at%Ru and a magnetic film the presentation of the target used for formation of the CoRu alloy substrate film was set to Co-12at%Cr-10at%Pt. The die length of the a-axis of Co alloy magnetic film of this presentation was 0.255 nm. 100nm and a carbon protective coat set [Ru substrate film / 30nm and the CoRu alloy substrate film / 50nm and Co alloy magnetic film] thickness of each film to 10nm. All the above-mentioned film formation was performed continuously, without breaking a vacuum within the same vacuum tub.
[0027] According to the X diffraction, magnetic properties were measured for the crystal orientation of the produced sample using the sample oscillatory type magnetometer (VSM), respectively. In the X diffraction, it turned out that the 0002 diffraction peak of Ru substrate film, the CoRu alloy substrate film, and Co alloy magnetic film is observed, and this film is carrying out [0001] orientation. When the locking curve of the X-ray 0002 diffraction peak of Co alloy magnetic film was measured, as compared with the magnetic-recording medium completely produced on the same conditions, without using the CoRu alloy substrate film for the magnetic-recording medium of this example, the half-value width of a locking curve was decreasing and the [0001] orientation of Co alloy magnetic film is improved. Improvement of the coercive force of a film surface perpendicular direction was carried out 13% (190Oe).
[0028] The improvement effect was accepted, also when it furthermore replaced with Ru substrate film and Ti substrate film was used. These results are shown in Table 2.
[0029]
[Table 2]

表　2

下地膜	X線ロッキング曲線の半値幅(度)	垂直方向の保磁力(Oe)
CoRu/Ru	2.5	1700
Ru (比較例)	3.6	1510
CoRu/Ti	2.7	1650
Ti (比較例)	3.5	1580

[0030] The magnetic recording medium by vertical magnetic recording as typically shown in drawing 5 R> 5 was produced using such a vertical-magnetic-recording medium. The vertical-magnetic-recording medium 51 is held by the holder which rotates by the motor, and the magnetic head 52 for informational writing and read-out is arranged corresponding to each

magnetic film of each. The location to the magnetic-recording medium 51 of this magnetic head 52 is moved with an actuator 53 and a voice coil motor 54. In order to control these furthermore, the record regenerative circuit 55, the positioning circuit 56, and the interface control circuit 57 are formed. The vertical-magnetic-recording medium using the CoRu substrate film confirmed that high density record was possible.

[0031] <Example 3> Diameter 1.8 The magnetic-recording medium with cross-section structure as shown in drawing 4 was produced by the ion beam sputtering method using the glass substrate of an inch. The first substrate film 42 which consists of Ru, 42', the second substrate film 43 which consists of a CoRu alloy, 43', Co alloy magnetic film 44, 44', the carbon protective coat 45, and 45' are formed in both sides of a substrate 41 in this sequence.

[0032] It formed in membrane formation using argon gas on conditions with a substrate temperature [of 260 degrees C], and a membrane formation rate of 50nm/m. Sputtering of Co target and the Ru target was independently carried out to formation of the CoRu alloy substrate film using two ion guns, and membranes were formed to coincidence. By controlling the membrane formation rate of Ru, the concentration of Ru in the film was continuously changed in the direction of thickness. The presentation of the target used for formation of a magnetic film was set to Co-12at%Cr-10at%Pt. The die length of the a-axis of Co alloy magnetic film of this presentation was 0.255nm. 100nm and a carbon protective coat set [Ru substrate film / 30nm and the CoRu alloy substrate film / 50nm and Co alloy magnetic film] thickness of each film to 10nm. All the above-mentioned film formation was performed continuously, without breaking a vacuum within the same vacuum tub.

[0033] Magnetic properties were measured for change of the presentation of the crystal orientation of the produced sample of the direction of thickness by the X diffraction with Auger electron spectroscopy using the sample oscillatory type magnetometer (VSM), respectively. In the X diffraction, it turned out that the 0002 diffraction peak of Ru substrate film, the CoRu alloy substrate film, and Co alloy magnetic film is observed, and this film is carrying out [0001] orientation. When the locking curve of the X-ray 0002 diffraction peak of Co alloy magnetic film was measured, as compared with the magnetic-recording medium completely produced on the same conditions, without using the CoRu alloy substrate film for the magnetic-recording medium of this example, the half-value width of a locking curve was decreasing 35%, and the [0001] orientation of Co alloy magnetic film is improved. Ru concentration was decreasing gently-sloping toward the film front face, and presentation distribution of the direction of thickness of the CoRu alloy substrate film was Co-46at%Ru near the interface with Co-72at%Ru and Co alloy magnetic film near the interface with Ru substrate film.

[0034] When the die length of the a-axis of the CoRu alloy of this presentation is estimated, it is 0.260nm near an interface with 0.265nm and Co alloy magnetic film near an interface with Ru substrate film. The amount of misfit of a grid estimated from this value is -1.8% in the interface of the CoRu alloy substrate film and Co alloy magnetic film -4.0% at the interface of Ru substrate film and the CoRu alloy substrate film. Improvement also of the coercive force of a film surface perpendicular direction was carried out 21% (310Oe).

[0035] <Example 4> Diameter 1.8 The magnetic-recording medium with cross-section structure as shown in drawing 6 was produced by the DC magnetron sputtering method using the glass substrate of an inch. Ti substrate film 62, 62', the Co-70at%Ru alloy substrate film 63, 63', the Co-40at%Ru alloy substrate film 64, 64', Co alloy magnetic film 65, 65', the carbon protective coat 66, and 66' are formed in both sides of a substrate 61 in this sequence. In advance of membrane formation, sputtering of the front face of a substrate was carried out with argon ion, and detailed boom hoisting with an average depth of about 2nm was formed. It formed in membrane formation using argon gas on conditions with a substrate temperature [of 250 degrees C], and a membrane formation rate of 50nm/m.

[0036] The presentation of the target used for formation of a magnetic film was set to Co-15at% Cr-5at%Ta. The die length of the a-axis of Co alloy magnetic film of this presentation was 0.251 nm. the thickness of each film -- 30nm and the Co-70at%Ru alloy substrate film were [100nm and a carbon protective coat] to 25nm, and 25nm and Co alloy magnetic film could be [Ti substrate film / the Co-40at%Ru alloy substrate film] 10nm. All the above-mentioned film

formation was performed continuously, without breaking a vacuum within the same vacuum tub.
[0037] By the X diffraction, magnetic properties were measured for the crystal orientation of the produced sample using the sample oscillatory type magnetometer (VSM), respectively. In the X diffraction, it turned out that the 0002 diffraction peak of Ti substrate film, the CoRu alloy substrate film, and Co alloy magnetic film is observed, and this film is carrying out [0001] orientation.
[0038] When the locking curve of the X-ray 0002 diffraction peak of Co alloy magnetic film was measured, as compared with the magnetic-recording medium completely produced on the same conditions, without using the CoRu alloy substrate film for the magnetic-recording medium of this example, the half-value width of a locking curve was decreasing 27%, and the [0001] orientation of Co alloy magnetic film is improved. The amount of misfit of the grid in this case is the interface of -10%, the Co-70at%Ru alloy substrate film, and the Co-40at%Ru alloy substrate film at the interface of Ti substrate film and the Co-70at%Ru alloy substrate film. - It is the interface of 2.2 %, and the Co-40at%Ru alloy substrate film and Co alloy magnetic film. - It is 2.9 %. As compared with the magnetic-recording medium completely produced on the same conditions, without using the CoRu alloy substrate film, improvement also of the coercive force of a film surface perpendicular direction was carried out 8% (130Oe).
[0039] The magnetic recording medium by vertical magnetic recording as typically shown in drawing 5 was produced using this vertical-magnetic-recording medium. Stable record playback was able to be performed by the effectiveness of detailed boom hoisting of a substrate front face, without the magnetic head fixing on a medium front face.
[0040]
[Effect of the Invention] Like this invention, by using a CoRu alloy for the substrate film, the c-axis perpendicular stacking tendency of Co alloy magnetic film can be raised, and the vertical-magnetic-recording medium of high performance which fitted high density record conventionally can be offered.

[Translation done.]

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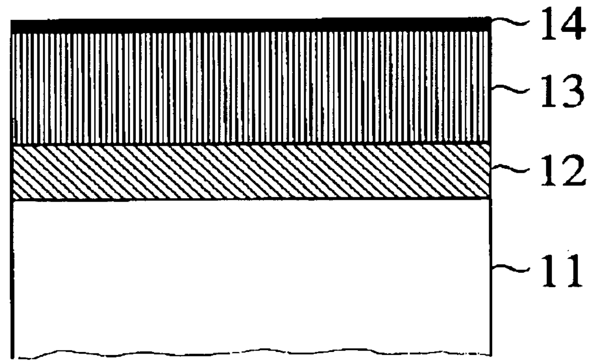
最終頁に続く

(54)【発明の名称】　垂直磁気記録媒体及び磁気記録装置

(57)【要約】
【目的】垂直磁気異方性の大きな垂直磁気記録媒体を提供する。
【構成】非磁性基板１１上に、ＣｏとＲｕの合金からなる下地膜１２，Ｃｏ合金磁性膜１３，保護膜１４を形成する。
【効果】Ｃｏ合金磁性膜の、ｃ軸垂直配向性及び垂直磁気異方性が向上し、高密度記録に適した垂直磁気記録媒体を提供できる。

図１



【特許請求の範囲】

【請求項１】非磁性基板と，前記非磁性基板上に形成された下地膜と，前記下地膜上に形成されたＣｏを主成分とする合金からなる垂直磁化膜と，前記垂直磁化膜上に形成された保護膜とからなる垂直磁気記録媒体において、前記下地膜がＣｏとＲｕの合金からなることを特徴とする垂直磁気記録媒体。

【請求項２】非磁性基板と，前記非磁性基板上に形成された第一の下地膜と，前記第一の下地膜上に形成された第二の下地膜と，前記第二の下地膜上に形成されたＣｏを主成分とする合金の垂直磁化膜と，前記垂直磁化膜上に形成された保護膜とからなる垂直磁気記録媒体において、前記第一の下地膜がＴｉまたはＲｕのいずれかからなり、前記第二の下地膜がＣｏとＲｕの合金からなることを特徴とする垂直磁気記録媒体。

【請求項３】請求項２において、ＣｏとＲｕの合金からなる前記下地膜が、Ｒｕの濃度の異なる二層の膜からなり、前記垂直磁化膜の直下に位置する層のＲｕ濃度が、その直下に位置する層のＲｕ濃度よりも低い垂直磁気記録媒体。

【請求項４】請求項２に記載の垂直磁気記録媒体における、前記ＣｏとＲｕの合金からなる下地膜において、Ｒｕの濃度が、前記非磁性基板に近い側から前記垂直磁化膜側に向かって、連続的に低下している垂直磁気記録媒体。

【請求項５】請求項１から４のいずれかに記載の垂直磁気記録媒体における、前記ＣｏとＲｕの合金からなる下地膜において、Ｒｕの濃度が、４０ａｔ％Ｒｕ以上である垂直磁気記録媒体。

【請求項６】請求項１，２，３または４において、前記各下地膜の優先配向方位と、前記垂直磁化膜の優先配向方位が、ともに［０００１］である垂直磁気記録媒体。

【請求項７】請求項１，２，３または４において、前記非磁性基板の表面に微細な起伏を設けた垂直磁気記録媒体。

【請求項８】請求項１，２，３，４，５，６または７に記載の垂直磁気記録媒体，前記垂直磁気記録媒体を保持するための保持具，前記垂直磁気記録媒体に情報を記録，再生するための磁気ヘッド，前記磁気ヘッドと前記垂直磁気記録媒体の相対位置を移動させるための移動手段、及びこれら各部を制御するための制御手段を有する磁気記録装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、高密度磁気記録に適する磁性膜を備えた垂直磁気記録媒体及びそれを用いた磁気記録装置に関する。

【０００２】

【従来の技術】情報化社会の発展を背景に、大量の情報を蓄積し、高速に入出力することのできる磁気記録装置への要求はますます高まっている。より多くの情報をコンパクトに記録するために、従来から用いられている面内磁気記録方式に代わって、さらに記録密度を向上できる新たな記録方式として、垂直磁気記録方式が注目を集めてきた。

【０００３】垂直磁気記録は、記録媒体の表面に対して垂直方向に形成した磁化を記録単位とする記録方式で、磁化反転部分で反磁界の影響が小さくなるため、高密度記録に適していると考えられる。これはアイイーイーイー　トランザクションズ　オン　マグネティクス（IEEE Transactions on Magnetics），ＭＡＧ－１３(1977)１２７２頁の論文に記述されている。この垂直磁気記録に用いる記録媒体は、媒体表面に垂直な方向に磁化容易軸を持ち、かつ大きな磁気異方性を持つ必要がある。このため、基板上に垂直磁化膜を形成した薄膜媒体の研究開発が行われてきた。

【０００４】垂直磁気記録媒体の記録膜には、磁気異方性の大きいＣｏ合金を用いることが、従来から検討されてきた。ＣｏＣｒ合金等のＣｏ合金は、六方最密充填構造を持ち、そのｃ軸を磁化容易軸とする一軸磁気異方性を示す。ガラスなどの非晶質基板の表面に、Ｃｏ合金の薄膜を形成すると、原子の最稠密面である(０００１)面が基板面に平行になりやすく、［０００１］配向した多結晶薄膜が得られる。この膜は、垂直磁気異方性を示すが、垂直磁気記録媒体として用いるには、さらに大きな磁気異方性を持たせることが必要であった。

【０００５】そこで、基板上に下地膜を設けて、Ｃｏ合金磁性膜のｃ軸配向性を向上させる試みがなされてきた。Ｔｉ等の六方最密充填構造を持つ薄膜は、［０００１］配向しやすいため、これを下地膜として用い、Ｃｏ合金磁性膜の配向性を改善できることが報告されている。Ｔｉ下地膜を用いた垂直磁気記録媒体に関しては、IEEE Transactions on Magnetics，ＭＡＧ－１９(１９８３)１６４４頁に記載の論文に記述されている。

【０００６】ところが、このようなＴｉ下地膜上に形成したＣｏ合金磁性膜のｃ軸の分散の大きさも、十分小さいとはいえなかった。この原因は、ＴｉとＣｏ合金の格子定数の差が１５％と大きいため、Ｃｏ合金の初期成長時に配向性が乱れるためであると考えられる。そこで、Ｃｏ合金磁性膜のｃ軸配向性をさらに向上させるための新たな下地膜の開発が望まれていた。

【０００７】

【発明が解決しようとする課題】本発明の目的は、従来の下地膜上に形成したＣｏ合金膜に比べて、さらに結晶配向性に優れ、垂直磁気異方性の大きな、垂直磁気記録媒体を提供すること、及びそれを用いた磁気記録装置を提供することにある。

【０００８】

【課題を解決するための手段】本発明の垂直磁気記録媒体は、図１に示すように、非磁性基板１１と，基板上に

形成された下地膜１２と，下地膜上に形成されたＣｏを主成分とする合金の垂直磁化膜１３と，垂直磁化膜上に形成された保護膜１４とからなる垂直磁気記録媒体であって、下地膜の材料がＣｏとＲｕの合金であることを特徴とする。

【０００９】本発明の垂直磁気記録媒体の第二の特徴は、図２に示すように、非磁性基板２１と，基板上に形成された第一の下地膜２２と，第一の下地膜上に形成された第二の下地膜２３と，第二の下地膜上に形成されたＣｏを主成分とする合金の垂直磁化膜２４と，垂直磁化膜上に形成された保護膜２５とからなる垂直磁気記録媒体であって、第一の下地膜がＴｉまたはＲｕのいずれかからなり、第二の下地膜がＣｏとＲｕの合金からなることにある。

【００１０】本発明の第二の構成の垂直磁気記録媒体では、（１）ＣｏとＲｕの合金からなる下地膜が、Ｒｕの濃度の異なる二層の膜からなり、垂直磁化膜の直下に位置する層のＲｕ濃度が、この層の直下に位置する層のＲｕ濃度よりも小さいこと、（２）ＣｏとＲｕの合金からなる下地膜で、Ｒｕの濃度が、基板に近い側から垂直磁化膜側に向かって、連続的に低下していること、のいずれかを満足する構成としてもよい。

【００１１】本発明の第一，第二の構成の垂直磁気記録媒体では、ＣｏとＲｕの合金からなる下地膜は、Ｒｕの濃度が４０ａｔ％Ｒｕ以上であることに特徴がある。

【００１２】また本発明の第一，第二の構成の垂直磁気記録媒体では、垂直磁化膜１３及び２４と，下地膜１２，２２、及び２３がいずれも［０００１］優先方位配向をしていることに特徴がある。

【００１３】さらに本発明の第一，第二の構成の垂直磁気記録媒体では、基板１１及び２１の表面に微細な起伏を設けた構成としてもよい。

【００１４】本発明の磁気記録装置は、上記で説明した第一，第二の構成による垂直磁気記録媒体，垂直磁気記録媒体を保持するための保持具，垂直磁気記録媒体に情報を記録，再生するための磁気ヘッド，磁気ヘッドと垂直磁気記録媒体の相対位置を移動させるための移動手段、及びこれら各部を制御するための制御手段から構成される。

【００１５】

【作用】上記の構成に用いるＣｏＲｕ合金は、常温で全組成範囲にわたって固溶体をつくることが知られている。結晶構造はＣｏ及びＲｕと同じく六方最密充填構造である。ガラス基板やＮｉＰをコーティングしたＡｌ合金基板のような非晶質の表面を持つ基板上にこの合金の薄膜を形成すると、（０００１）面が基板に平行になり、ｃ軸が垂直配向しやすい。このため、垂直磁気記録媒体の記録膜として用いるＣｏ合金磁性膜のｃ軸垂直配向性を向上させるための下地膜として用いることができる。Ｒｕの濃度が４０ａｔ％以上の組成域では、キュリー温度が０℃以下になるため、この合金は強磁性を示さなくなる。非磁性の下地膜として用いる場合、Ｒｕの濃度が４０ａｔ％Ｒｕ以上の範囲で用いるのが適切である。

【００１６】ＣｏＲｕ合金の格子定数は、合金の組成に比例して連続的に変化する。Ｃｏ及びＲｕのａ軸の格子定数はそれぞれ０．２５１ｎｍ，０．２７０ｎｍである。Ｃｏ－４０ａｔ％Ｒｕの格子定数は０．２５９　ｎｍである。したがって、Ｃｏ－４０ａｔ％Ｒｕの合金を下地膜に用いれば、Ｃｏ合金磁性膜（ａ軸の格子定数が約０．２５ｎｍ)との格子定数の差は、ＣｏＲｕ合金を基準にして－３％と小さくなる。したがって、この合金を下地膜として用いると、Ｃｏ合金の初期成長時の配向の乱れを防止し、ｃ軸垂直配向性の高い垂直磁化膜を作製することができる。

【００１７】Ｒｕ及びＴｉは、ｃ軸垂直配向しやすいが、Ｃｏ合金磁性膜とのａ軸の格子定数の差は、Ｒｕを下地膜に用いる場合は、－７％、Ｔｉを用いる場合は、－１５％となり、ＣｏＲｕ合金の場合に比べていずれも大きい。そこでＴｉあるいはＲｕの下地膜を形成した後、その表面にＣｏＲｕ合金下地膜を形成することにより、格子定数差を緩和し、Ｃｏ合金の格子定数に近い格子定数を持つ下地膜を作製することができる。

【００１８】さらに、ＣｏＲｕ合金下地膜を、Ｒｕ濃度の異なる二層の膜からなる構成とし、ＴｉあるいはＲｕの下地膜上にＲｕ濃度の高い層を形成し、その表面にＲｕ濃度の低い層を形成することで、効果的に格子定数差を緩和することができる。また、ＣｏＲｕ合金下地膜のＲｕ濃度を、基板に近い側から垂直磁化膜側に向かって、連続的に低下させることによっても、格子定数差を緩和することができる。

【００１９】このように、Ｃｏ合金磁性膜のａ軸の格子定数に近い格子定数を持つＣｏＲｕ合金を、下地膜に用いることにより、Ｃｏ合金磁性膜のｃ軸垂直配向性を高め、従来よりも高密度記録に適した垂直磁気記録媒体を提供できる。

【００２０】

【実施例】

<実施例１>直径２．５　インチのガラス基板を用い、図３に示すような断面構造を持つ磁気記録媒体を、ＤＣマグネトロンスパッタリング法によって作製した。基板３１の両面に、ＣｏＲｕ合金下地膜３２，３２′，Ｃｏ合金磁性膜３３，３３′，カーボン保護膜３４，３４′をこの順序で形成する。

【００２１】成膜には、アルゴンガスを用い、ガスの圧力０．７　Ｐａ，基板温度２６０℃，成膜速度毎分５０ｎｍの条件で形成した。下地膜の形成に用いるターゲットの組成はＣｏ－４０ａｔ％Ｒｕ，磁性膜の形成に用いるターゲットの組成はＣｏ－１５ａｔ％Ｃｒ－５ａｔ％Ｔａとした。この組成のＣｏ合金磁性膜のａ軸の長さは

０．２５１　ｎｍであった。各膜の膜厚は、ＣｏＲｕ合金下地膜が５０ｎｍ，Ｃｏ合金磁性膜が１００ｎｍ，カーボン保護膜が１０ｎｍとした。上記の膜形成はすべて同一の真空槽内で真空を破ることなく連続して行った。

【００２２】作製した試料の結晶配向をＸ線回折によって、磁気特性を試料振動型磁力計（ＶＳＭ）を用いてそれぞれ測定した。Ｘ線回折では、ＣｏＲｕ合金下地膜及びＣｏ合金磁性膜の０００２回折ピークが観測され、この膜が［０００１］配向していることがわかった。Ｃｏ合金磁性膜のＸ線０００２回折ピークのロッキング曲線を測定したところ、本実施例の磁気記録媒体は、下地膜を用いずに全く同様の条件で作製した磁気記録媒体と比較して、ロッキング曲線の半値幅が減少しており、Ｃｏ合金磁性膜の［０００１］配向が改善されていた。膜面垂直方向の保磁力は３８％（４２０Ｏｅ）向上した。

【００２３】さらに下地膜にＣｏ－５０ａｔ％Ｒｕ合金，Ｃｏ－７５ａｔ％Ｒｕ合金を用いた場合にも、改善効果が認められた。これらの結果を表１に示す。

【００２４】

【表１】

表　１

下　地　膜	ａ軸の長さ（ｎｍ）	Ｘ線ロッキング曲線の半値幅（度）	垂直方向の保磁力（Ｏｅ）
Ｃｏ－４０ａｔ％Ｒｕ	０．２５９	２．８	１５２０
Ｃｏ－５０ａｔ％Ｒｕ	０．２６１	３．１	１４９０
Ｃｏ－７５ａｔ％Ｒｕ	０．２６５	３．１	１４７０
なし（比較例）		８．５	１１００

【００２５】〈実施例２〉直径１．８ インチのＮｉＰをコーティングしたＡｌ合金基板を用い、図４に示すような断面構造を持つ磁気記録媒体を、ＤＣマグネトロンスパッタリング法によって作製した。基板４１の両面に、Ｒｕからなる第一の下地膜４２，４２′，ＣｏＲｕ合金からなる第二の下地膜４３，４３′，Ｃｏ合金磁性膜４４，４４′，カーボン保護膜４５，４５′をこの順序で形成する。

【００２６】成膜には、アルゴンガスを用い、ガスの圧力０．７　Ｐａ，基板温度２６０℃，成膜速度毎分５０ｎｍの条件で形成した。ＣｏＲｕ合金下地膜の形成に用いるターゲットの組成はＣｏ－４０ａｔ％Ｒｕ，磁性膜の形成に用いるターゲットの組成はＣｏ－１２ａｔ％Ｃｒ－１０ａｔ％Ｐｔとした。この組成のＣｏ合金磁性膜のａ軸の長さは０．２５５　ｎｍであった。各膜の膜厚は、Ｒｕ下地膜が３０ｎｍ，ＣｏＲｕ合金下地膜が５０ｎｍ，Ｃｏ合金磁性膜が１００ｎｍ，カーボン保護膜が１０ｎｍとした。上記の膜形成はすべて同一の真空槽内で真空を破ることなく連続して行った。

【００２７】作製した試料の結晶配向をＸ線回折によって、磁気特性を試料振動型磁力計（ＶＳＭ）を用いてそれぞれ測定した。Ｘ線回折では、Ｒｕ下地膜，ＣｏＲｕ合金下地膜及びＣｏ合金磁性膜の０００２回折ピークが観測され、この膜が［０００１］配向していることがわかった。Ｃｏ合金磁性膜のＸ線０００２回折ピークのロッキング曲線を測定したところ、本実施例の磁気記録媒体は、CoRu合金下地膜を用いずに全く同様の条件で作製した磁気記録媒体と比較して、ロッキング曲線の半値幅が減少しており、Ｃｏ合金磁性膜の［０００１］配向が改善されていた。膜面垂直方向の保磁力は１３％（１９０Ｏｅ）向上した。

【００２８】さらにＲｕ下地膜に代えて、Ｔｉ下地膜を用いた場合にも、改善効果が認められた。これらの結果を表２に示す。

【００２９】

【表２】

表　２

下　地　膜	Ｘ線ロッキング曲線の半値幅（度）	垂直方向の保磁力（Ｏｅ）
ＣｏＲｕ／Ｒｕ	２．５	１７００
Ｒｕ（比較例）	３．６	１５１０
ＣｏＲｕ／Ｔｉ	２．７	１６５０
Ｔｉ（比較例）	３．５	１５８０

【００３０】このような垂直磁気記録媒体を用いて、図５に模式的に示すような垂直磁気記録方式による磁気記録装置を作製した。垂直磁気記録媒体５１は、モータにより回転する保持具により保持され、それぞれの各磁性膜に対応して情報の書き込み，読み出しのための磁気ヘッド５２が配置されている。この磁気ヘッド５２の磁気記録媒体５１に対する位置をアクチュエータ５３とボイスコイルモータ５４により移動させる。さらにこれらを制御するために記録再生回路５５，位置決め回路５６，インターフェース制御回路５７が設けられている。Ｃｏ

Ｒｕ下地膜を用いた垂直磁気記録媒体で、高密度記録が可能であることを確かめた。

【００３１】〈実施例３〉直径１．８ インチのガラス基板を用い、図４に示すような断面構造を持つ磁気記録媒体を、イオンビームスパッタリング法によって作製した。基板４１の両面に、Ｒｕからなる第一の下地膜４２，４２′，ＣｏＲｕ合金からなる第二の下地膜４３，４３′，Ｃｏ合金磁性膜４４，４４′，カーボン保護膜４５，４５′をこの順序で形成する。

【００３２】成膜には、アルゴンガスを用い、基板温度２６０℃，成膜速度毎分５０ｎｍの条件で形成した。ＣｏＲｕ合金下地膜の形成には、二つのイオン銃を用い、Ｃｏターゲットとやターゲットを独立にスパッタリングして同時に成膜した。Ｒｕの成膜速度を制御することによって、膜中のＲｕの濃度を、膜厚方向に連続的に変化させた。磁性膜の形成に用いるターゲットの組成はＣｏ－１２ａｔ％Ｃｒ－１０ａｔ％Ｐｔとした。この組成のCo合金磁性膜のａ軸の長さは０．２５５ｎｍであった。各膜の膜厚は、Ｒｕ下地膜が３０ｎｍ，ＣｏＲｕ合金下地膜が５０ｎｍ，Ｃｏ合金磁性膜が１００ｎｍ，カーボン保護膜が１０ｎｍとした。上記の膜形成はすべて同一の真空槽内で真空を破ることなく連続して行った。

【００３３】作製した試料の結晶配向をＸ線回折で、膜厚方向の組成の変化をオージェ電子分光法により、磁気特性を試料振動型磁力計（ＶＳＭ）を用いてそれぞれ測定した。Ｘ線回折では、Ｒｕ下地膜，ＣｏＲｕ合金下地膜及びＣｏ合金磁性膜の0002回折ピークが観測され、この膜が［０００１］配向していることがわかった。Ｃｏ合金磁性膜のＸ線０００２回折ピークのロッキング曲線を測定したところ、本実施例の磁気記録媒体は、ＣｏＲｕ合金下地膜を用いずに全く同様の条件で作製した磁気記録媒体と比較して、ロッキング曲線の半値幅が３５％減少しており、Ｃｏ合金磁性膜の［０００１］配向が改善されていた。ＣｏＲｕ合金下地膜の膜厚方向の組成分布は、膜表面に向かってＲｕ濃度がなだらかに減少しており、Ｒｕ下地膜との界面付近でＣｏ－７２ａｔ％Ｒｕ，Ｃｏ合金磁性膜との界面付近でＣｏ－４６ａｔ％Ｒｕであった。

【００３４】この組成のＣｏＲｕ合金のａ軸の長さを見積もると、Ｒｕ下地膜との界面付近で０．２６５ｎｍ，Ｃｏ合金磁性膜との界面付近で０．２６０ｎｍである。この値から見積もった、格子のミスフィット量は、Ｒｕ下地膜とＣｏＲｕ合金下地膜の界面で－４．０％，ＣｏＲｕ合金下地膜とＣｏ合金磁性膜の界面で－１．８％である。膜面垂直方向の保磁力も２１％（３１０Ｏｅ）向上した。

【００３５】〈実施例４〉直径１．８ インチのガラス基板を用い、図６に示すような断面構造を持つ磁気記録媒体を、ＤＣマグネトロンスパッタリング法によって作製した。基板６１の両面に、Ｔｉ下地膜６２，６２′，Ｃｏ－７０ａｔ％Ｒｕ合金下地膜６３，６３′，Ｃｏ－４０ａｔ％Ｒｕ合金下地膜６４，６４′，Ｃｏ合金磁性膜６５，６５′，カーボン保護膜６６，６６′をこの順序で形成する。成膜に先立ち、基板の表面をアルゴンイオンによってスパッタリングし、平均深さ約２ｎｍの微細な起伏を形成した。成膜には、アルゴンガスを用い、基板温度２５０℃，成膜速度毎分５０ｎｍの条件で形成した。

【００３６】磁性膜の形成に用いるターゲットの組成はCo－１５ａｔ％Ｃｒ－５ａｔ％Taとした。この組成のＣｏ合金磁性膜のａ軸の長さは０．２５１ ｎｍであった。各膜の膜厚は、Ｔｉ下地膜が３０ｎｍ，Ｃｏ－７０ａｔ％Ｒｕ合金下地膜が２５ｎｍ，Ｃｏ－４０ａｔ％Ｒｕ合金下地膜が２５ｎｍ，Ｃｏ合金磁性膜が１００ｎｍ，カーボン保護膜が１０ｎｍとした。上記の膜形成はすべて同一の真空槽内で真空を破ることなく連続して行った。

【００３７】作製した試料の結晶配向をＸ線回折で、磁気特性を試料振動型磁力計(ＶＳＭ)を用いてそれぞれ測定した。Ｘ線回折では、Ｔｉ下地膜，ＣｏＲｕ合金下地膜及びＣｏ合金磁性膜の０００２回折ピークが観測され、この膜が［０００１］配向していることがわかった。

【００３８】Ｃｏ合金磁性膜のＸ線０００２回折ピークのロッキング曲線を測定したところ、本実施例の磁気記録媒体は、ＣｏＲｕ合金下地膜を用いずに全く同様の条件で作製した磁気記録媒体と比較して、ロッキング曲線の半値幅が２７％減少しており、Ｃｏ合金磁性膜の［０００１］配向が改善されていた。この場合の格子のミスフィット量は、Ｔｉ下地膜とＣｏ－７０ａｔ％Ｒｕ合金下地膜の界面で－１０％，Ｃｏ－７０ａｔ％Ｒｕ合金下地膜とＣｏ－４０ａｔ％Ｒｕ合金下地膜の界面で－２．２ ％，Ｃｏ－４０ａｔ％Ｒｕ合金下地膜とＣｏ合金磁性膜の界面で－２．９ ％である。膜面垂直方向の保磁力も、ＣｏＲｕ合金下地膜を用いずに全く同様の条件で作製した磁気記録媒体と比較して８％（１３０Ｏｅ）向上した。

【００３９】この垂直磁気記録媒体を用いて、図５に模式的に示すような垂直磁気記録方式による磁気記録装置を作製した。基板表面の微細な起伏の効果で、磁気ヘッドが媒体表面に固着することなく、安定した記録再生が行えた。

【００４０】

【発明の効果】本発明のように、ＣｏＲｕ合金を下地膜に用いることにより、Ｃｏ合金磁性膜のｃ軸垂直配向性を高め、従来よりも高密度記録に適した高性能の垂直磁気記録媒体を提供することができる。

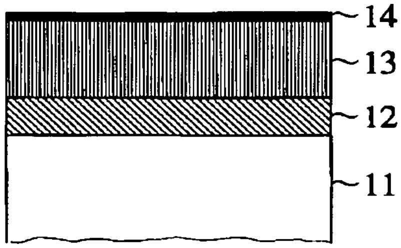
【図面の簡単な説明】

【図１】本発明の第一の実施例の垂直磁気記録媒体の断面構造の説明図。

【図２】本発明の第二の実施例の垂直磁気記録媒体の断面構造の説明図。
【図３】本発明の第一の実施例の垂直磁気記録媒体の断面構造の説明図。
【図４】本発明の第二の実施例の垂直磁気記録媒体の断面構造の説明図。
【図５】本発明の磁気記録装置のブロック図。
【図６】本発明の第三の実施例の垂直磁気記録媒体の断面構造の説明図。
【符号の説明】
１１…非磁性基板、１２…ＣｏＲｕ合金下地膜、１３…Ｃｏ合金磁性膜、１４…保護膜。

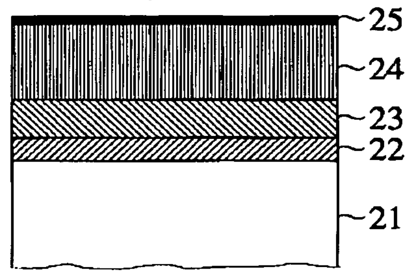
【図１】

図１



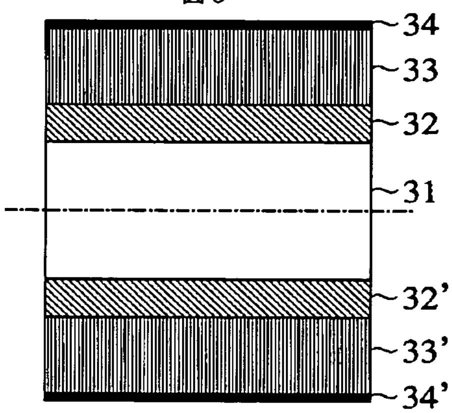
【図２】

図２



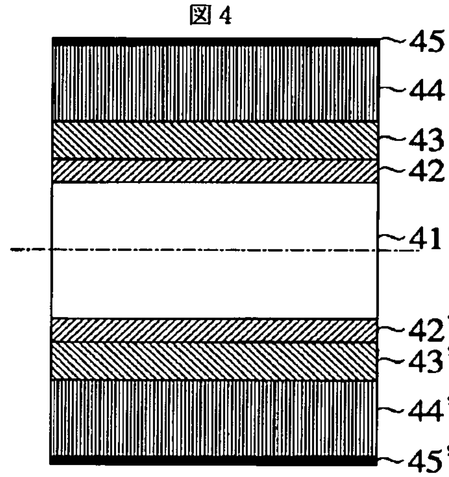
【図３】

図３



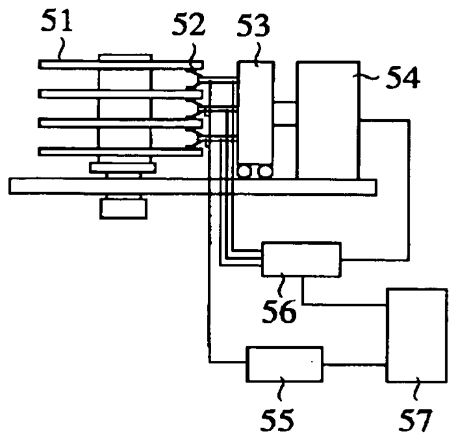
【図４】

図４



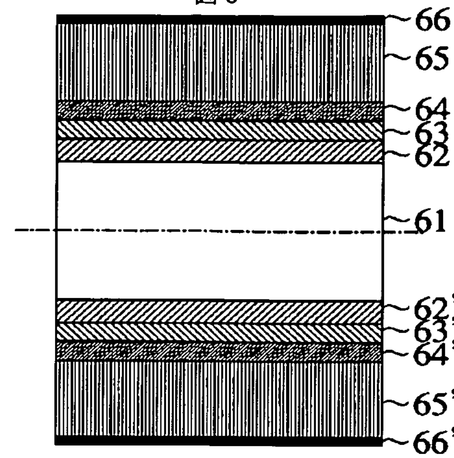
【図5】

図5



【図6】

図6



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